

CHAPTER 7. REASSESSMENT and MONITORING PROGRAM

7.1 Introduction

The Klamath River TMDLs and implementation plan will be adaptively managed in consideration of the changing status of water quality and beneficial uses in the Klamath River basin, the effectiveness of the implementation programs in achieving the TMDL allocations and targets, and any necessary refinements to the technical TMDL analysis. The Klamath River TMDL reassessment and monitoring plan is designed to provide critical feedback to inform the adaptive management process. Because of the linkage between the Klamath River TMDLs and monitoring workgroups such, as the Klamath Basin Monitoring Program (KBMP) and the Statewide and Klamath Blue-Green Algae Work Groups, the Regional Water Board is in a good position to be aware of and act upon any new information or mitigation practices that could help to restore and protect water quality conditions in the Klamath River.

7.2 Klamath River TMDL Reassessment

Within five years of USEPA approval of the Klamath River TMDL, and every five years thereafter, the Regional Water Board staff will conduct a comprehensive assessment of the effectiveness of implementation of the Klamath River TMDL Action Plan and Lost River Implementation Plan. During these reassessments, the Regional Water Board will consider how effective the implementation actions have been at achieving water quality objectives and protecting the beneficial uses of the Klamath River basin.

The primary measure of success for TMDL implementation is attainment of water quality standards. The Klamath River TMDL establishes clear and reasonable numeric targets and allocations that can be used to track progress towards restoration of supporting water quality conditions. However, recognizing that many factors may affect the attainment of water quality standards and the TMDL, other measures of success will also be considered in evaluating the implementation program such as annual reports, nonpoint source pollution control implementation programs, BMP implementation status, evaluations submitted by responsible parties, and other available information.

The Regional Water Board may conclude that ongoing implementation efforts are insufficient to ultimately achieve the allocations and numeric targets. If the Regional Water Board makes this determination, responsible parties may be required to improve and increase their reporting, monitoring, and/or implementation efforts, as necessary, to ensure any applicable allocations and numeric targets are achieved within a reasonable amount of time. Individual landowners conducting nonpoint source discharge activities are only responsible for their own discharges. The Regional Water Board may otherwise conclude, at the time of review, that implementation efforts are expected to result in achieving water quality standards and the allocations and numeric targets. In that case, responsible parties must continue to implement existing and anticipated reporting, monitoring, and implementation efforts. Responsible parties will continue monitoring according to this plan for at least five more years, at which time the Regional Water

Board will determine the need for continuing or otherwise modifying the monitoring requirements. Monitoring and assessment results (see for instance Section 7.8 regarding special study considerations) may also demonstrate that water quality standards can be achieved without full attainment of the TMDL allocations and targets. Alternatively, monitoring and assessment results may demonstrate that although water quality objectives are not being achieved in receiving waters, controllable sources of pollutants are not contributing to the exceedance. In these cases, the Regional Water Board may re-evaluate the numeric targets and allocations in the TMDL.

Regional Water Board staff will also report back to the Regional Board as necessary on the status and progress of the implementation programs, and the timeframes within which current efforts are reasonably expected to achieve water quality standards. The reports will assess:

- Water quality improvement,
- BMP implementation,
- BMP effectiveness/performance,
- Level of compliance with measures and timeframes established in the implementation plan, and
- Level of compliance with measures and timelines agreed to in responsible party water quality management plans developed pursuant to the TMDL implementation plan.

Table 7.1 shows the water quality metrics and initial timelines that will be used to assess TMDL implementation. Collection of water quality data will be coordinated with ongoing Klamath monitoring programs organized through the KBMP as described later in this chapter. The timelines for attainment of the various TMDL allocations and targets are meant as guides for the Regional Water Board to evaluate the success of the Klamath TMDL. They were selected based on staff estimates of the time needed for basinwide implementation of management measures necessary for TMDL attainment. In some cases, the timelines for compliance may be refined based on further evaluation of potential compliance mechanisms and/or refinement of the TMDL analysis. For some larger dischargers, the implementation plan requires the development of implementation plans that include timelines for implementing management measures to achieve the TMDLs. These dischargers will periodically report to the Regional Water Board on progress. The Regional Water Board may at that time require modification of the discharger's plan and/or timelines as necessary.

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Table 7.1: Basinwide water quality trends

Parameter	Water Quality Metric	Location(s)	Timeline
Temperature – Numeric	Numeric targets – Daily average temperatures (use MWAT and MWMT statistics for spring, mid-, and late summer)	Stateline and critical location(s) in mainstem.	40 years
	Numeric targets – Daily average temperatures (use MWAT and MWMT statistics for spring, mid-, and late summer)	Reservoir tailraces	40 years
	Compliance lens biological optimum for different life stages measured as MWAT and MWMT statistics for spring, mid-, and late summer.	In reservoirs	Coinciding with schedule for volitional fish passage if Sec Det. is negative 2020 if Sec Det. is affirmative
	No change in natural temperatures due to reservoirs (use daily mean, max, and minimum statistics).	Upstream and downstream of reservoirs	2014 if Sec Det. is negative 2020 if Sec Det. is affirmative
	Iron Gate Hatchery monthly mean temperature	Hatchery discharge	Per NPDES permit
	Thermal Refugia temperatures	In key thermal refugia in Klamath during critical period	Trend tracking, no TMDL allocation or target
Dissolved oxygen	Monthly means of the daily minimum DO levels.	Stateline, below Salmon River and other critical locations in mainstem Klamath River (summer).	20 years
	Compliance lens	Copco 1 and Iron Gate	Coinciding with schedule for volitional fish passage if Sec Det. is negative 2020 if Sec Det. is affirmative
Dissolved oxygen	Dissolved oxygen as mean and minimum Reservoir	tailraces	2014
	Iron Gate Hatchery dissolved oxygen as monthly mean and minimum	Hatchery discharge	Per NPDES permit
Nutrients and Organic Matter	Numeric targets as monthly mean concentrations	Stateline and below Salmon River. Copco 1 and 2 and Iron Gate Reservoirs and tailraces	20 years
	Nutrient load reductions assigned to KHP facilities in California	Upstream of Copco 1 and at Iron Gate tailrace	Based on PacifiCorp implementation plan, subject to Regional Water Board approval
	Iron Gate Hatchery numeric targets as monthly mean concentrations	Hatchery discharge	Per NPDES permit
Chlorophyll <i>a</i>	10 ug/L growing season average	Copco 1 and 2 and Iron Gate Reservoirs	20 years
<i>Microcystis aeruginosa</i>	Cell density relative to blue-green algae biomass and cells/L. Microcystin Toxin	Copco 1 and 2 and Iron Gate Reservoirs and in mainstem at critical locations	Based on PacifiCorp implementation plan subject to Regional Water Board approval
Periphyton Chlorophyll <i>a</i>	Numeric targets for chlorophyll <i>a</i> density	Below Salmon River and below Iron Gate Dam	20 years
Fish disease spore counts	Per the KBMP – may include other water quality parameters found to be related to spread of fish disease	At disease hot spots	

7.3 Klamath Basin Water Quality Monitoring Program

The purpose of the remainder of this chapter are: 1) to provide a description of a larger basinwide monitoring program; and 2) present an initial design for a monitoring plan that is specific to the California Klamath River TMDL. The two purposes have significant overlap because the Regional Water Board will integrate the California Klamath River TMDL monitoring plan into the larger basinwide program monitoring plan. Both monitoring plans are essential for an adaptive management program to restore and protect beneficial uses within the Klamath River, and are described briefly below:

- The basin wide monitoring plan initiative (described in Section 7.2) is a broader program for monitoring and assessment for the entire Klamath River basin. The basinwide component calls for data collection and compilation into a common database from all of the subbasins within the Klamath River basin, including the Lost River. This component of the monitoring program is based on the *Review Draft: Klamath Basin Water Quality Monitoring Plan*, Prepared for the Klamath Basin Monitoring Program (KBMP) (Royer and Stubblefield 2009).
- The California Klamath River TMDL monitoring plan (described in Sections 7.3-7.5) provides the initial structure and details for a TMDL specific monitoring plan to assess status and trends for compliance with the Klamath River TMDL targets and allocations within California. This component of the monitoring program is based on the recently completed AIP Interim Measure 12¹: *Water Quality Monitoring Activities – Monitoring Year 2009* (Royer and Stubblefield 2009).

This two-tiered strategy recognizes the need for a coordinated basinwide understanding of the resource use and resource protection issues outlined in the National Research Council recommendations (NRC 2004). The strategy is to integrate the TMDL specific monitoring plan into the emerging more comprehensive basinwide monitoring coordination network.

7.3.1 Components of the TMDL Monitoring Program

The primary purposes of the TMDL monitoring program are to evaluate water quality conditions and trends with respect to the TMDL targets and allocations, and to determine the status of beneficial use support in the California reaches of the Klamath River.

¹ On November 13, 2008, the United States, the States of California and Oregon, and PacifiCorp executed an Agreement in Principle (AIP) describing the framework for an approach to study the water quality conditions of the Klamath River pursuant to the possible removal of several PacifiCorp's dams on the Klamath River. Interim Measure 12 of the AIP stipulates to a water quality monitoring program, including on-going public health monitoring of blue-green algae (cyanobacteria) and associated toxins. Interim Measure 12 of the AIP further stipulates that PacifiCorp will provide funding of \$500,000 per year for this measure, and that monitoring will be performed by an entity or entities agreed upon by the parties to the AIP and in consultation with the appropriate water quality agencies.

Support for these assessments will require various types of monitoring including:

- **Compliance and Trend Monitoring** is intended to determine, on a watershed scale, if water quality objectives are being met, and if beneficial uses are being protected from the adverse effects of one or more pollutants. This will require stations to be established at specific compliance points identified in the TMDL (compliance) and at locations of special beneficial use and water quality condition sensitivity (trend). The sampling frequency and density should be of a high enough resolution so that over a reasonable period time it can be determined whether management actions are having the desired effect on water quality conditions.
- **Public Health Monitoring** is a special subset of compliance and trend monitoring. Due to the seasonal presence of toxins associated with blue-green algae blooms in Iron Gate and Copco Reservoirs and in the river below Iron Gate Dam, the Klamath River TMDL monitoring plan includes public health monitoring activities to alert agencies to potentially hazardous conditions, and will provide them with information for posting health advisories as part of a public outreach and education program.
- **Implementation Monitoring** assesses whether activities and control practices were carried out as planned. For the Klamath River TMDL, examples of control practices may include construction of treatment wetlands, wetland restoration, and follow up to practices covered under existing or new permits. Implementation Monitoring activities are site-specific and can be as simple as a photographic record of activities.
- **Special Studies** address key questions, unknowns, or uncertainties that require more than an ambient water quality monitoring program to provide the information necessary for a more complete understanding of a water quality issue. Special studies can be critical to the adaptive management process to resolve issues related to changes in management practices. Examples of key questions to be addressed through special studies include: the relationship between fish disease and water quality conditions; nutrient mass balance to better understand the sources and sinks of nutrients and organic matter within the Klamath River basin; role of upstream blue-green algal sources for inoculation of downstream waters; improved characterization of periphyton conditions on Klamath River reaches below Iron Gate Dam; among others.
- **Project Effectiveness Monitoring** is similar to Implementation Monitoring and is keyed to an assessment of whether individual projects achieve the environmental benefits expected of them. Constructed wetlands and improvements to irrigation return flow operations are examples of two types of projects that would include project effectiveness monitoring as part of any grant funding.

The primary focus of this section is on public health monitoring (section 7.4), compliance and trend monitoring (Section 7.5), and key questions for future special studies (Section 7.6).

7.3.2 Monitoring Program Organization

Section 7.4 provides an overview of the emerging Klamath Basin Monitoring Program (KBMP) framework. Section 7.5 provides a summary of the monitoring stations, compliance points, and station objectives for the TMDL monitoring plan for California. Section 7.6 describes the public health components of the TMDL monitoring plan for California. Section 7.7 then describes the ambient trend and compliance component of the TMDL monitoring plan for California. Section 7.8 presents key questions to be addressed through recommended special studies. Section 7.9 describes how the Klamath River TMDL will be reassessed and potentially updated in coming years.

7.4. Overview of the Klamath Basin Monitoring Program Framework

The State Water Board and Regional Water Board, with funding and technical support from the USEPA, initiated a contract to facilitate the development of a coordinated monitoring and assessment program within the Klamath River basin. Much of the material in this section is adapted from the “*Review Draft: Klamath Basin Water Quality Monitoring Plan*, Prepared for the Klamath Basin Monitoring Program (KBMP)” (Royer and Stubblefield 2009).

The development of the multi-party Klamath River basin water quality monitoring program has been facilitated by the Klamath Watershed Institute, an affiliate of Humboldt State University. The KBMP consists of representatives from multiple agencies, Tribes, and organizations. A comprehensive list of participating entities is presented in Table 7.2. The KBMP has worked together over the past two years to develop a Draft *Klamath Basin Water Quality Monitoring Plan*. The Draft *Klamath River Basin Water Quality Monitoring Plan* is a working document intended to be updated as the needs of the KBMP change over time. It is the hope that a coordinated monitoring effort will support decisions made in the Klamath River basin regarding resource management, including such things as: implementation measures to achieve TMDL allocations and targets; appropriate conditions for the operation of PacifiCorp’s Klamath Hydroelectric Project and the U.S. Bureau of Reclamation’s (USBR) Klamath Project; nonpoint source (NPS) pollution controls; and how to expedite the recovery of impaired beneficial uses for the benefit of all California and Oregon residents and Tribal communities.

Many of the goals outlined by the Regional Water Board and ODEQ are echoed in the KBMP goals and objectives. The KBMP Water Quality Subcommittee drafted goals and objectives that seek to develop and maintain a network of sites that capture the status and trends of selected indicators throughout the basin over time and space. The backbone of the network is built on legacy sites identified by organizations conducting monitoring in the basin as well as sites identified in the TMDL implementation plan.

The evaluation of the current monitoring effort was based upon a review of TMDL listings at a subbasin level, and other monitoring conducted by participating organizations within the basin. Since TMDL listings are based on water quality impairment to

beneficial uses, sampling at the subbasin scale may be evaluated for meeting the goals and objectives of the Regional Water Board, ODEQ and KBMP.

Table 7.2: Members of the KBMP as of March 18, 2008

Aquatic Ecosystem Sciences, LLC	PacifiCorp
Board of Supervisors Siskiyou Co.	Quartz Valley Indian Reservations
Bureau of Land Management	Resighini Rancheria
California Department of Fish and Game	Salmon River Restoration Council
California Department of Health Services	Scott River Watershed Council
California Dept of Water Resources	Shasta Valley Resource Conservation District
California EPA- State Water Resources Control Board	Siskiyou County
U.S. Dept of the Interior	Siskiyou County Public Health
E&S Environmental	Siskiyou Resource Conservation District
U.S. Environmental Protection Agency	Southern Oregon University
French Creek Watershed Advisory Group	Sprague Watershed Council
Hoopa Valley Tribal EPA	The Nature Conservancy
Humboldt State University	Timber Products Company
Karuk Tribe	U. S. Bureau of Reclamation
Kier Associates	USDA - Natural Resources Conservation Service
Klamath Compact	U. S. Fish and Wildlife Service
Klamath National Forest	U. S. Forest Service
Klamath River Keeper	U. S. Geological Survey
Klamath Tribes	University of California Berkeley
Mid Klamath Watershed Council	University of California Santa Cruz
National Oceanic and Atmospheric Administration	University of Texas
National Park Service	Upper Mid Klamath Watershed Council
North Coast Regional Water Quality Control Board	Watercourse Engineering, Inc
Oregon Department of Environmental Quality	Watershed Initiatives LLC
Oregon State University- Dept of Microbiology	Yurok Tribe Environmental Program

7.4.1 Overview of the Klamath Basin Monitoring Program (KBMP)

The parties comprising the KBMP recognize the value of coordinating monitoring programs throughout the Klamath River basin and that collaboration among agencies, organizations and tribal governments is essential to protecting the health of the basin. Given the complexity and severity of the problems facing the basin, and the decreasing level of available resources at all levels, there is a clear need for this effort. To this end, the KBMP is working to develop a collaborative monitoring program for the basin that will:

- improve short- and long-term collaboration on annual water quality monitoring activities in the Klamath River basin to support beneficial uses and improve understanding of the ecology of the basin;
- develop and maintain a network of long-term monitoring sites that capture status and trends of selected indicators throughout the basin over time and space;
- develop a sustainable monitoring program for the Klamath River basin that does not replace individual water quality monitoring efforts but expands coordinated monitoring in a way that benefits long-term collaboration;

- include all agencies and organizations that engage in water quality monitoring in the Klamath River basin;
- develop consistency in quality assurance and control regarding all monitoring activities;
- develop and maintain a system to encourage the transfer and sharing of fundamental water quantity and quality information amongst monitoring organizations needed to inform water resources studies;
- establish an online clearinghouse for housing and disseminating water quality monitoring data as well as other information about the Klamath River basin and planning and restoration efforts, allowing users to contribute, access and download data;
- create protocols for providing data and information in a timely manner to better inform adaptive management; and
- identify and communicate monitoring program results and research needs to its members, research institutions, the public, and policy makers.

Another common goal of the Regional Water Board and ODEQ is to identify and document the effects of climate change on water quality within the basin. In the state of California, climate change is expected to dramatically alter water resource availability in both time and location. The California Climate Change Center predicts increased temperature, reduced snowpack, truncated rainy season and increased fire frequency and severity (CCCC 2006). There is currently a data gap concerning the implications of climate change on the Klamath River basin.

7.4.2 KBMP Monitoring Plan Statement of Purpose

The purpose of the Klamath River Basin Water Quality Monitoring Plan is to serve as a collaborative and comparable plan for sampling and analyzing water quality in the Klamath River basin.

This comprehensive approach seeks to include all agencies and organizations engaging in water quality monitoring in the Klamath River basin. The Klamath River Basin Water Quality Monitoring Plan is not intended to replace individual water quality monitoring efforts or autonomy, but to expand coordinated monitoring in a way that benefits long-term coordination and collaboration in the basin.

The development of the Klamath River Basin Water Quality Monitoring Plan consists of a review of existing efforts and identification of data gaps, recommended enhancements, implementation of comparable Quality Assurance and Quality Control (QA/ QC) using multistate (Oregon and California) guidelines, and development of a sustainable monitoring and funding framework that addresses both long and short-term needs.

7.4.3 KBMP Monitoring Plan Goals

KBMP members developed the following goals to guide the development of the comprehensive water quality monitoring plan for the Klamath River basin:

- Coordinate monitoring activities to inform TMDL development and progress towards goals;
- Develop and maintain long-term monitoring network of sites that capture status and trends of selected indicators throughout the basin over time and space;
- Frame monitoring objectives by subbasin in terms of supporting beneficial uses and improving the understanding of the ecology of the Klamath basin;
- Strive for consistent quality assurance and control regarding all monitoring activities;
- Provide accessible data in a timely manner to better inform regulatory agencies, organizations, tribal community and the public; and
- Identify and document the effects of climate change and supply data to support climate change models to enhance the understanding of future impacts on water quality within the basin.

7.4.4 Description of Current KBMP Members Monitoring Efforts and Maps

The current collection of water quality data in the Klamath River basin is a multi-organizational effort. While there has been some informal coordination and collaboration amongst members of various organizations, many entities have worked independently on discrete projects addressing water quality issues. The Klamath Watershed Institute (KWI) compiled an inventory of organizations conducting water quality monitoring and the location of these monitoring activities in the Klamath River basin. These organizations are listed in Table 7.3. From this comprehensive list, members of the KBMP selected a subset of sites for inclusion in the Klamath River Basin Water Quality Monitoring Plan that is illustrated in Figure 7.1.

Table 7.3: Organizations collecting water quality data in the Klamath River basin as of February 15, 2009

California Department of Water Resources	The Nature Conservancy
Hoopa Tribe	Timber Products Company
Karuk Tribe	University of California Santa Cruz
Klamath Tribes	U. S. Bureau of Reclamation
Oregon Department of Environmental Quality	U. S. Bureau of Land Management
PacifiCorp U	U. S. Environmental Protection Agency
North Coast Regional Water Quality Control Board	U. S. Fish and Wildlife Service
Quartz Valley Indian Reservation	U. S. Forest Service
Salmon River Restoration Council	U. S. Geological Survey
Scott River Conservation District	Yurok Tribe
Shasta Valley Resource Conservation District	

7.4.5 Schedule for Completion of the Klamath River Basin Coordinated Water Quality Monitoring Plan

The final Klamath River Basin Water Quality Monitoring was completed in December 2009. In addition to having the final Klamath River Basin Water Quality Monitoring Plan, the framework will also include a web portal for uploading and accessing data. This portal will be managed by a third party. Regional Water Board staff recommend that the California Klamath River TMDL monitoring recommendations be included in the final Klamath River Basin Water Quality Monitoring Plan.

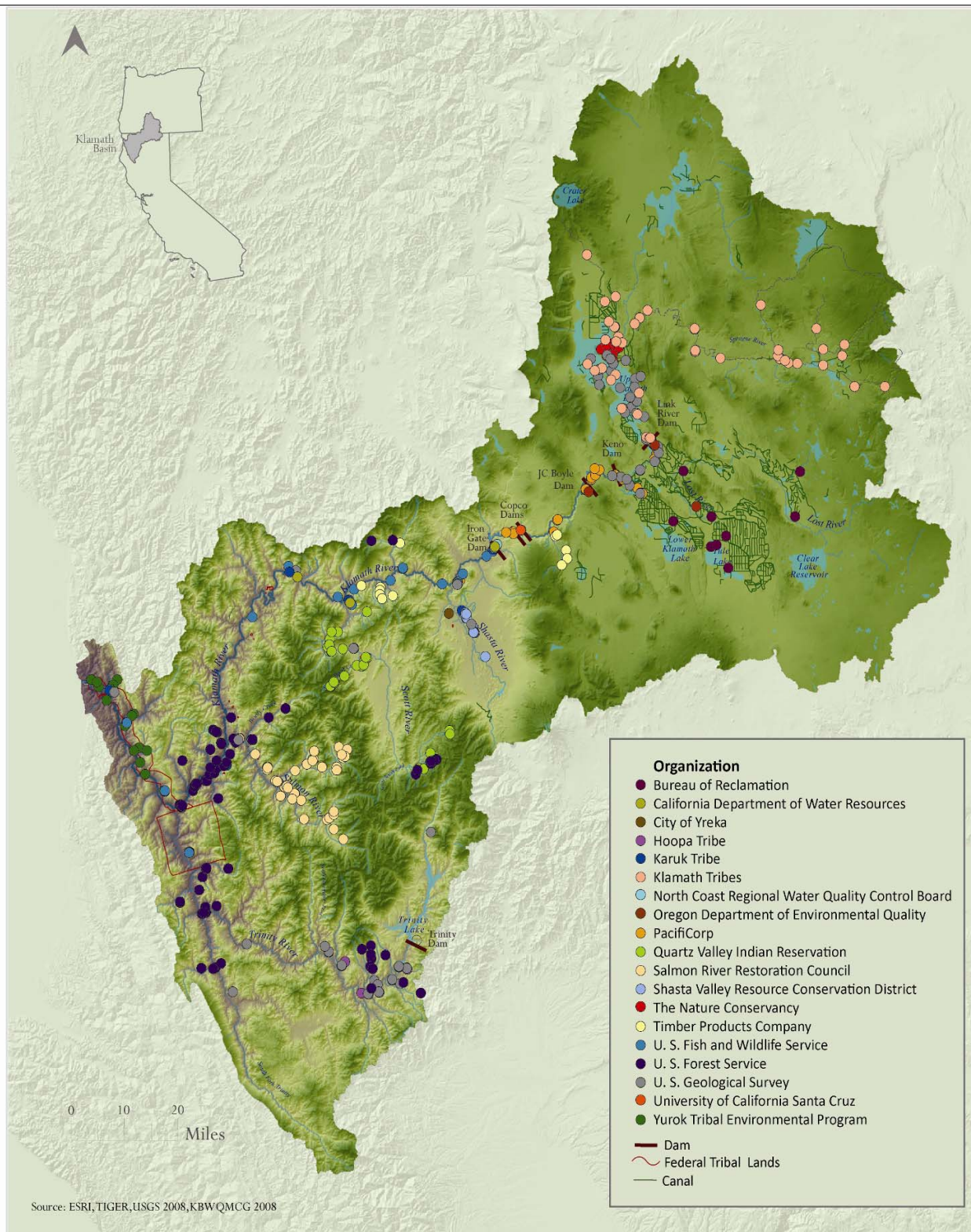


Figure 7.1: KBMP monitoring sites in 2008 by organization Source: Royer and Stubbelfield 2009

Note: The sites from the Link Dam to Keno Dam are incorrectly identified as U.S. Geologic Survey sights, and are actually sites monitored by the U.S. Bureau of Reclamation.

7.5 California Klamath River TMDL Monitoring Stations, Compliance Points, and Station Objectives

Chapter 5 presents the allocations and targets for the California Klamath River TMDL. Those allocations (**A**) or targets (**T**) are assigned at specific locations within the Klamath River basin that are considered to be compliance points for the TMDL. That is, sources will be evaluated regarding the success of their controls based on conditions at the compliance locations. This monitoring plan also calls for additional monitoring stations within the Klamath River mainstem. Table 7.4 includes a summary of all of the proposed monitoring locations and monitoring components, and presents a rationale and purpose for each location.

For the purposes of addressing TMDL compliance, the compliance locations are the highest priority for conducting monitoring activities. Stations are also noted for public health (**PH**) and special studies (**SS**). Special study stations have been included to better understand water quality processes, beneficial use support status, and to address key questions (see Section 7.6) important to adaptive management decisions. Not all monitoring objectives described for specific monitoring locations in Table 7.4 are represented by an A, T, PH, or SS indicator. The locations of the compliance monitoring public health and special study stations for the California Klamath River TMDL are illustrated in Figure 7.2. More detailed descriptions of public health and trend monitoring are provided in Sections 7.4 and 7.5.

7.6 Public Health Monitoring

This section addresses monitoring to evaluate risks to public health associated with TMDL impairments. Due to the seasonally high concentrations of cyanobacteria and associated toxins in the reservoirs and downstream of Iron Gate Dam, the Regional Water Board is including a public health monitoring component in the California Klamath River TMDL monitoring plan. This section presents protocols to be used in conducting sampling for public health monitoring, including sampling locations, frequency and procedures. The information included in this section has been adapted from the *AIP Interim Measure 12: Water Quality Monitoring Activities Monitoring Year 2009* (AIP June 2009). This plan was developed through collaboration among the Regional Water Board; ODEQ; PacifiCorp; USEPA Region 9; USBR; Karuk Tribe Natural Resources Department; and Yurok Tribe Environmental Program, with support from the Klamath Watershed Institute. Members of the KBMP reviewed earlier drafts of the AIP 2009 Monitoring Plan. The AIP Monitoring Plan will be updated each year involving the same collaborators listed above with review by other interested parties from the KBMP. As described earlier the plan was developed in part to address TMDL objectives and information needs.

Table 7.4: California Klamath TMDL monitoring locations, parameters, and objectives

Location (River Mile; Station ID) ¹	Monitoring Parameter: Allocations (A); Targets (T); Public Health (PH) & Special Studies (SS)	Rationale / Purpose
Klamath River above Shovel Creek - Stateline (206.4; KR2064)	Temperature ² (A & T) TN, TP, CBOD ³ (A) Chlorophyll –a ⁴ (T) Dissolved Oxygen ⁵ (T)	<ul style="list-style-type: none"> ▪ This station is a compliance point for both targets (temperature and dissolved oxygen), and allocations (nutrients and organic matter). ▪ Represents both Klamath River at Stateline and Klamath River above Copco Reservoir. (“Stateline” has been represented by agencies and other entities as the Klamath River above Shovel Creek for several years.) ▪ Location provides opportunity to assess nutrient, organic matter, and chl-a loads generated in the upper basin including Upper Klamath Lake and Lost River and provides information on critical period concentrations entering the reservoirs. ▪ Assessment point for chlorophyll-a concentrations downstream of JC Boyle and prior to entering quiescent waters of Copco and Iron Gate Reservoirs. ▪ Evaluates temperature of that water entering CA which should not be elevated above natural temperature (expressed as monthly average). ▪ Assess if dissolved oxygen concentrations are at or above 85% saturation under natural temperature conditions⁶.
Copco Reservoir - several stations including outlet (199.0; KR1990)	Temperature (A & T) TN, TP, CBOD (T) Chlorophyll –a (T, PH & SS) Dissolved Oxygen (A & T) <i>Microcystis aeruginosa</i> cell density ⁶ (T, PH & SS) Microcystin toxin ⁶ (T, PH & SS)	<ul style="list-style-type: none"> ▪ These stations are compliance points for targets (TN, TP, CBOD, chlorophyll-a, <i>Microcystis aeruginosa</i>, and microcystin) and allocations (TN and TP). ▪ Multiple stations to assess public health risk due to cyanobacteria (blue-green algae) critical period blooms in both water column and fish tissue. This objective will require the addition of special studies. ▪ Assess for presence of dissolved oxygen and temperature compliance lens. ▪ Monitor for potential temperature impacts of reservoir impoundments and transfer of these impacts downstream. ▪ Assess nutrient dynamics for potential release of nutrients from reservoir sediments during critical growth period.
Downstream of Copco Reservoir (195.0; KR1950)	TN, TP, CBOD (A) Dissolved Oxygen (A) <i>Microcystis aeruginosa</i> cell density (T, PH) Microcystin toxin (T, PH) Periphyton (SS)	<ul style="list-style-type: none"> ▪ Contribute to an improved nutrient and organic mass balance for the reservoirs.

Table 7.4(cont.): California Klamath TMDL monitoring locations, parameters, and objectives

Location (River Mile; Station ID)¹	Monitoring Parameter: Allocations (A); Targets (T); Public Health (PH) & Special Studies (SS)	Rationale / Purpose
Iron Gate Reservoir - several stations including outlet (192.0; KR1920)	Temperature (A & T) TN, TP, CBOD (T) Chlorophyll –a (T) Dissolved Oxygen ⁵ (A&T) <i>Microcystis aeruginosa</i> cell density (T, PH) Microcystin toxin (T, PH)	<ul style="list-style-type: none"> These stations are compliance points for targets (TN, TP, CBOD, chlorophyll-a, <i>Microcystis aeruginosa</i>, and microcystin) Multiple stations to assess public health risk due to cyanobacteria (blue-green algae) critical period blooms in both water column and fish tissue. Assess for presence of dissolved oxygen and temperature compliance lens. Monitor for potential temperature impacts of reservoir impoundments and transfer of these impacts downstream. Assess nutrient dynamics for potential release of nutrients from reservoir sediments during critical growth period.
Iron Gate Hatchery - Discharge locations	Temperature (A & T) TN, TP, CBOD (A & T) Dissolved Oxygen (T)	<ul style="list-style-type: none"> Track Iron Gate Hatchery discharge to evaluate compliance with NPDES / TMDL discharge requirements for nutrients, organic matter, and temperature. Monitoring requirements will be specified in revised NPDES permit
Klamath River below Iron Gate Dam -Hatchery Bridge (189.7; KR1897)	TN, TP, CBOD (SS) Dissolved Oxygen (SS) <i>Microcystis aeruginosa</i> cell density (PH) Microcystin toxin (PH)	<ul style="list-style-type: none"> Trend monitoring for dissolved oxygen, temperature, nutrients, and organic matter. Public health water column monitoring related to cyanotoxins generated within reservoirs. Fish tissue sampling to assess exposure of salmonids to microcystin. Evaluate temperature regime effect of reservoirs.
Klamath River at Shasta River at Walker Bridge (176.7; KR1767)	TN, TP, CBOD (SS) Dissolved Oxygen (SS) <i>Microcystis aeruginosa</i> cell density (PH) Microcystin toxin (PH)	<ul style="list-style-type: none"> Trend compliance monitoring for nutrients, organic matter, dissolved oxygen, and temperature. Public health monitoring related to cyanotoxins including water and tissue samples.
Klamath river at Brown Bear River Access (157.5; KR1575)	TN, TP, CBOD (SS) Dissolved Oxygen (SS) <i>Microcystis aeruginosa</i> cell density (PH) Microcystin toxin (PH) Periphyton (SS)	<ul style="list-style-type: none"> Public health monitoring related to cyanotoxins including water and tissue samples. Trend monitoring for nutrients, organic matter, dissolved oxygen, temperature. Measure periphyton densities to assess impact on: 1) water quality (e.g., DO, pH); 2) stream nutrient dynamics; and 3) increases in parasite densities. Special studies to better understand relationship between water quality conditions and prevalence of fish diseases below Iron Gate Dam.

Table 7.4 (cont.): California Klamath TMDL monitoring locations, parameters, and objectives

Location (River Mile; Station ID)¹	Monitoring Parameter: Allocations (A); Targets (T); Public Health (PH) & Special Studies (SS)	Rationale / Purpose
Klamath River at Seiad Valley (128.5; KR1285)	TN, TP, CBOD (SS) Dissolved Oxygen (SS) <i>Microcystis aeruginosa</i> cell density (PH) Microcystin toxin (PH)	<ul style="list-style-type: none"> ▪ Trend compliance monitoring for nutrients, organic matter, dissolved oxygen, and temperature. ▪ Public health monitoring related to cyanotoxins including water and tissue samples.
Klamath River at Happy Camp (108.4; KR0935)	TN, TP, CBOD (SS) Dissolved Oxygen (SS) <i>Microcystis aeruginosa</i> cell density (PH) Microcystin toxin (PH) Periphyton (SS)	<ul style="list-style-type: none"> ▪ Trend compliance monitoring for nutrients, organic matter, dissolved oxygen, and temperature. ▪ Public health monitoring related to cyanotoxins including water and tissue samples. ▪ Measure periphyton densities to assess impact on: 1) water quality (e.g., DO, pH); 2) stream nutrient dynamics; and 3) increases in parasite densities. ▪ Special studies to better understand relationship between water quality conditions and prevalence of fish diseases below Iron Gate Dam.
Klamath River at Orleans (59.1; KR0591)	TN, TP, CBOD (SS) Dissolved Oxygen (SS) <i>Microcystis aeruginosa</i> cell density (PH) Microcystin toxin (PH)	<ul style="list-style-type: none"> ▪ Trend compliance monitoring for nutrients, organic matter, dissolved oxygen, and temperature. ▪ Public health monitoring related to cyanotoxins including water and tissue samples.
Klamath River at Saints Rest Bar (44.5; KR0445)	TN, TP, CBOD (T) Dissolved Oxygen (T) <i>Microcystis aeruginosa</i> cell density (PH) Microcystin toxin (PH) Periphyton (T)	<ul style="list-style-type: none"> ▪ Evaluate compliance with Hoopa Valley Tribe Water Quality Criteria
Klamath River at Weitchpec (43.5; KR00425)	TN, TP, CBOD (SS) Dissolved Oxygen (SS) <i>Microcystis aeruginosa</i> cell density (PH) Microcystin toxin (PH)	<ul style="list-style-type: none"> ▪ Trend compliance monitoring for nutrients, organic matter, dissolved oxygen, and temperature. ▪ Public health monitoring related to cyanotoxins in water column.
Klamath River below Trinity River – above Tully Creek (38.5; KR0385)	TN, TP, CBOD (SS) Dissolved Oxygen (SS)	<ul style="list-style-type: none"> ▪ Trend compliance monitoring for nutrients, organic matter, dissolved oxygen, and temperature. ▪ Public health monitoring related to cyanotoxins including water and tissue samples.
Klamath River at Turwar (6.0; KR0060)	TN, TP, CBOD (SS) Dissolved Oxygen (SS) <i>Microcystis aeruginosa</i> cell density (PH) Microcystin toxin (PH)	<ul style="list-style-type: none"> ▪ Trend compliance monitoring for nutrients, organic matter, dissolved oxygen, <i>Microcystis aeruginosa</i>, microcystin, and temperature.

Table 7.4 (cont.): California Klamath TMDL monitoring locations, parameters, and objectives

Location (River Mile; Station ID)¹	Monitoring Parameter: Allocations (A); Targets (T); Public Health (PH) & Special Studies (SS)	Rationale / Purpose
Klamath River Estuary (0.5; KR0005)	TN, TP, CBOD (SS) Dissolved Oxygen (SS) <i>Microcystis aeruginosa</i> cell density (PH) Microcystin toxin (PH)	<ul style="list-style-type: none"> ▪ Trend compliance monitoring for nutrients, organic matter, dissolved oxygen, <i>Microcystis aeruginosa</i>, microcystin, and temperature.
Shasta River near mouth (SHR00)	TN, TP, CBOD (A) Dissolved Oxygen (T)	<ul style="list-style-type: none"> ▪ Trend compliance monitoring for nutrients, organic matter, dissolved oxygen, and temperature.
Scott River near mouth (SCR00)	TN, TP, CBOD (A) Dissolved Oxygen (T)	<ul style="list-style-type: none"> ▪ Trend compliance monitoring for nutrients, organic matter, dissolved oxygen, and temperature.
Salmon River near mouth (SAR00)	TN, TP, CBOD (A) Dissolved Oxygen (T)	<ul style="list-style-type: none"> ▪ Trend compliance monitoring for nutrients, organic matter, dissolved oxygen, and temperature.
Trinity River near mouth (TR00)	TN, TP, CBOD (A) Dissolved Oxygen (T) <i>Microcystis aeruginosa</i> cell density (PH)	<ul style="list-style-type: none"> ▪ Trend compliance monitoring for nutrients, organic matter, dissolved oxygen, and temperature. ▪ Public health monitoring related to cyanotoxins including water and tissue samples (control).
Watershed-wide (N/A)	Riparian Shade and Sediment (A & T)	<ul style="list-style-type: none"> ▪ Monitoring to evaluate status of riparian shade conditions relative to site-potential to track trends in effective shade levels for all Klamath tributaries. ▪ Assessment of human-caused mass wasting hazards (e.g., stream crossings) that have potential to contribute sediment delivery to streams above background levels that could contribute to channel alterations that affect stream temperature or fish refugia. ▪ Assess road conditions to ensure that best management practices are being implemented to reduce the incidence of road related landslides.

¹ River miles are approximate, and station ID's are per the KBMP.

² Temperature shall be monitored at hourly or sub-hourly interval.

³ Nutrient and organic matter grab samples shall be analyzed for inorganic nitrogen (ammonia, nitrite, nitrate), organic nitrogen, inorganic phosphorus (orthophosphate) organic phosphorus, and CBOD-ultimate. Allocations and targets expressed as monthly mean concentrations.

⁴ Surface grab samples shall be analyzed for chlorophyll-a ; the mean of bi-monthly growing season (June through September) sample results shall be calculated to assess compliance with the chlorophyll-a target.

⁵ Dissolved oxygen concentrations shall be monitored at hourly or sub-hourly intervals; targets and allocations based on 85% saturation at natural temperature.

⁶ Sampling procedures for *Microcystis aeruginosa* and microcystin are presented in Section 7.4.1.3.

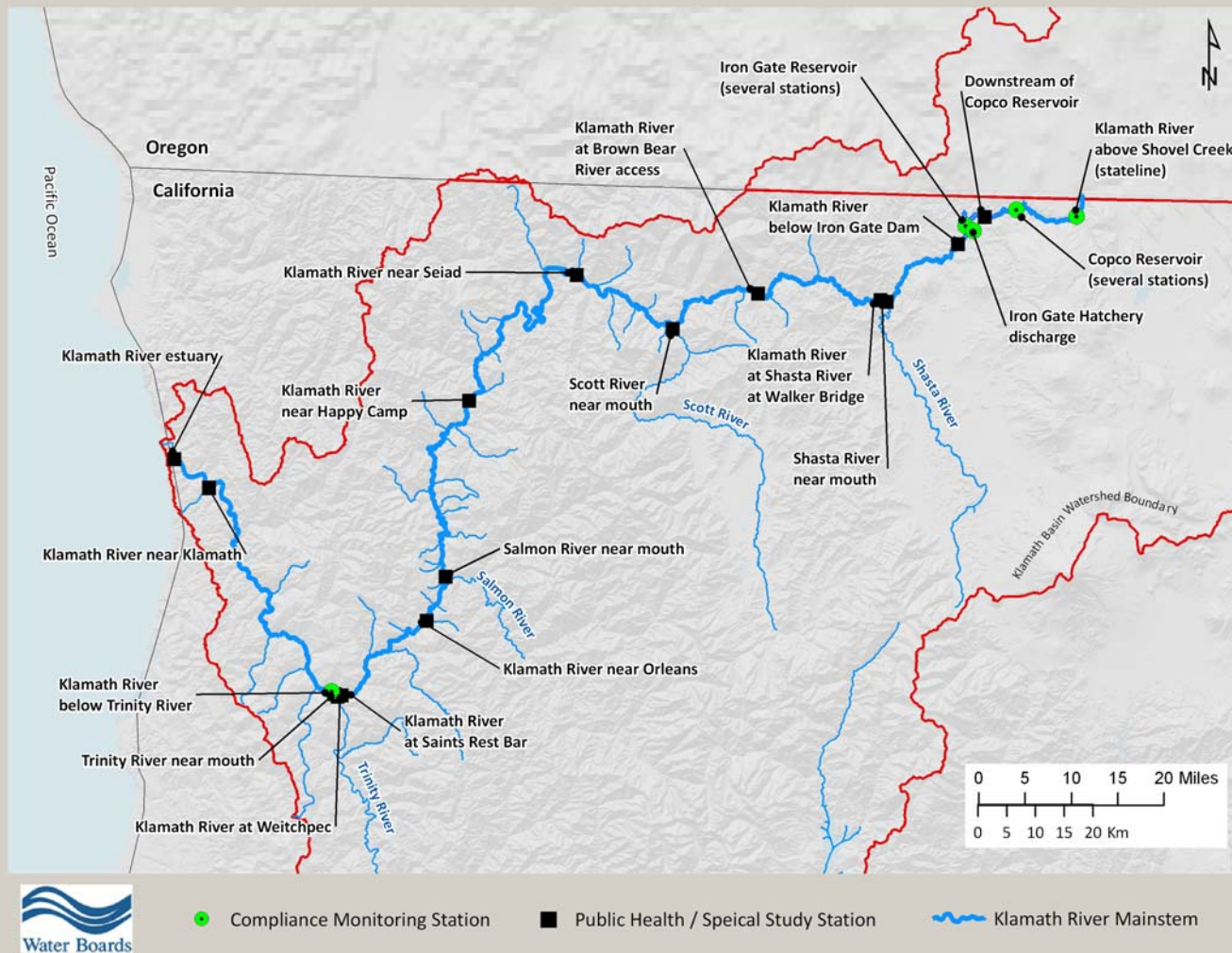


Figure 7.2: Location of California Klamath River TMDL monitoring stations – compliance, public health, and special study

Risks to public and ecological health related to cyanobacteria and cyanotoxin exposure will be evaluated through water sampling, tissue sampling, and identification of the presence of scums, using the monitoring procedures described in the standard operating procedures (SOPs) presented in Appendix A of the AIP 2009 Monitoring Plan (AIP 2009). Water quality monitoring of cyanobacteria and related cyanotoxins for purposes other than public and ecological health evaluation is addressed in Section 7.5.

The primary concern of this monitoring is public health. In addition to direct exposure to impacted waters (ingestion, inhalation and dermal exposures), exposures to microcystins are possible from ingestion of fish (e.g., caught during recreational fishing in the reservoirs), or consumption of freshwater mussels collected from the Klamath River. Mussels from the Klamath River are part of the traditional diet of tribal people. Additionally, mussels as filter feeders may be sensitive indicators of cyanobacteria levels and toxin levels in ambient water and food sources.

Cyanotoxins can also have an impact on the health of fish and other exposed species, which result in direct impacts to those species, as well as consumers of those impacted species including humans. Additionally, the information from the public health monitoring component can provide valuable information relative to other beneficial uses including the status of both COLD and WARM water beneficial uses. For example, microcystin concentrations in fish tissue can disrupt liver function in fish at levels considered to be moderate or low for human consumption. Therefore these measures should not be interpreted for human health assessments alone. Rather the results also should be applied to determine whether microcystin exposures are a contributing factor to ecological impacts such as fish disease and fish health both within the reservoirs and below Iron Gate Dam.

7.6.1 Water Sampling

7.6.1.1 Sampling Locations

Public health monitoring for cyanobacteria and microcystin toxin in water samples will occur at a total of 12 designated locations used for public access and recreation. These are listed in Table 7.5, and include:

- Four shoreline sites in coves on Copco (Mallard Cove and Copco Cove) and Iron Gate reservoirs (Camp Creek and Williams Boat Ramp). These cove sites provide public access, are known areas of likely accumulation during blooms, and have been monitored since 2005.
- Eight (8) river sites stretching from Iron Gate dam (RM 189.7) to Turwar (RM 6.0). Most of these sites have been monitored since 2005, and all represent areas of public access.

In recent years, monitoring programs have also been conducted to evaluate cyanobacteria and cyanotoxin levels in reaches of the Klamath River upstream of the Copco reservoirs, in Oregon between Upper Klamath Lake (Link River Dam) and Copco 1 Reservoir. Those locations are not addressed in this document.

Table 7.5: 2009 Klamath River sampling sites for public health monitoring of cyanobacteria and cyanotoxins in surface water samples and the entities responsible for 2009 sample collection

Location	Approx RM	Sampling Entity
Copco Reservoir and Mallard Cove	200.8	PacifiCorp
Copco Reservoir at Copco Cove	198.5	PacifiCorp
Iron Gate Reservoir at Camp Creek	192.8	PacifiCorp
Iron Gate Reservoir at Williams Boat Ramp	192.4	PacifiCorp
Klamath River below Iron Gate Dam (Hatchery Bridge)	189.7	PacifiCorp
Klamath River at I-5 Rest Area	176	Karuk
Klamath River at Brown Bear River Access	157.5	Karuk
Klamath River at Seiad Valley	128.5	Karuk
Klamath River at Happy Camp	108.4	Karuk
Klamath River at Orleans	59.1	Karuk
Klamath River at Weitchpec	43.5	Yurok
Klamath River at Turwar	6.0	Yurok

7.6.1.2 Sampling Frequency

Sampling frequencies for public health monitoring for both water and tissue samples under the 2009 plan are summarized in Table 7.6 and briefly discussed below:

1. Prior to and following cyanobacteria blooms, once per month (May and November).
2. During the presence of visible cyanobacterial populations or blooms, and cyanotoxins at levels approaching concentrations that warrant the posting of public health advisories by regulatory agencies (e.g., the Regional Water Board), biweekly (aka, every two weeks) (June through October). Sampling will continue at a biweekly frequency until State Board guidelines for posting have been met for *Microcystis aeruginosa*.
3. Following the posting of public health advisories for *Microcystis aeruginosa*, sampling at selected shoreline locations will be reduced to monthly until bloom densities and toxin levels in those areas have reduced and risks to public health are no longer a concern. Sampling at those locations will then resume as in Items 1 or 2, above, depending on the time of year.

7.6.1.3 Sampling Procedures

Water samples will be collected, by all reach monitoring entities, for species identification/enumeration, and for toxin analysis, in accordance with the *Standard Operating Procedures, Environmental Sampling of Cyanobacteria for cell enumeration, identification and toxin analysis* (AIP 2009 - Appendix A). To address public health concerns, water samples will be collected at sampling depths representative of reasonable maximum exposure by incidental ingestion exposures to sensitive populations (i.e., children).

Under the AIP 2009 Monitoring program, Microcystin toxins in water samples are being analyzed by the U.S. EPA Region 9 laboratory, in accordance with the U.S. EPA Region 9 Laboratory Standard Operating Procedure (SOP 1305 for Microcystin analysis by ELISA). In accordance with the *Environmental Sampling SOP* (Appendix A) samples

Table 7.6: Klamath River AIP monitoring program 2009 – summary table of public health monitoring locations, constituents, method, and frequency

Site ID	Location	Phyto-plankton Species	Microcystin - EPA	Fish Tissue	Mussel Tissue	LCMS microcystin confirmation	LCMS water for mussels	Sampling Entity
KR2008	Copco Reservoir at Mallard Cove	J/J1	M3/BM3	S2	-	BM5	-	PacifiCorp
KR1985	Copco Reservoir at Copco Cove	J/J2	M3/BM3	-	-	-	-	PacifiCorp
KR1928	Iron Gate Reservoir at Camp Creek	J/J2	M3/BM3	-	-	-	-	PacifiCorp
KR1924	Iron Gate Reservoir at Williams Boat Ramp	J/J1	M3/BM3	S2	-	-	-	PacifiCorp
KR1897	Klamath River below Iron Gate Dam (Hatchery Bridge)	BM/W BM	/W	-	-	-	-	PacifiCorp
KR1760	Klamath River at I-5 Rest Area	BM/W BM/W		-	S4	-	S4	Karuk
KR1575	Klamath River at Brown Bear River Access	BM/W BM/W		-	S4	-	S4	Karuk
KR1285	Klamath River at Seiad Valley	BM/W BM/W		-	S4	BM5	S4	Karuk
KR1084	Klamath River at Happy Camp	BM/W BM/W		-	S4	-	S4	Karuk
KR0591	Klamath River at Orleans	BM/W BM/W		-	S4	-	S4	Karuk
KR0435	Klamath River at Weitchpec	BM/W BM	/W	-	S4	-	S4	Yurok
KR0060	Klamath River at Turwar	BM/W	BM/W	-	S4	-	-	Yurok
TRR000	Trinity River near mouth	- -		-	SI	-	S1	Yurok

J/J1 June-July bimonthly rushed, than monthly phytoplankton through Nov

J/J2 June-July bimonthly rushed

M3/BM3 bimonthly June through October and monthly in May and November

BM/W bimonthly June through October, weekly Aug/Sept

S2 Two seasonal sampling events

S4 Four seasonal sampling events

S1 One seasonal sampling event

BM5 bimonthly June through October

should be chilled immediately upon collection and maintained at or below 6 degrees C prior to and throughout shipping to the laboratory.

Water samples are also being collected for cyanobacterial cell identification/enumeration to determine the presence and abundance of cyanobacterial species (e.g., *Anabaena sp.*, *Aphanizomenon sp.*, *Microcystis sp.*, etc). These analyses will be conducted to the species level at minimum. Depending on the severity (e.g., density and size) of the algal bloom, river monitoring entities will specify whether the phytoplankton analysis samples will be rushed and/or enumerated using a 400 cell count protocol.

Analysis and data QA/QC review and reporting are being conducted in accordance with the Quality Assurance (QA) plans requirements for each reach monitoring entity identified in Table 7.6 (QA plans are included in Appendix B to the AIP 2009 Monitoring Plan). Appendix B.

7.6.2 Tissue Sampling

During 2009, public health monitoring includes sampling of yellow perch from Copco and Iron Gate Reservoirs, and mussel sampling from locations on the Klamath River below Iron Gate Dam. Sampling conducted in the summer of 2007, with analysis by CDFG using LC/MS/MS, found levels of microcystin in mussels collected in the Klamath River below Iron Gate Dam, and in fish tissue (yellow perch) collected from Copco and Iron Gate reservoirs, exceeding the advisory level of 26 ng/g wet weight total microcystin/gram tissue, developed by the California Office of Environmental Health Hazard Assessment (letter dated August 6, 2008, to Randy Landolt, PacifiCorp from OEHHHA (OEHHHA 2008).

In 2008, PacifiCorp collected yellow perch and crappie samples from Iron Gate and Copco reservoirs, and rainbow trout from the Klamath River above Copco Reservoir and below Iron Gate dam prior to, during, and after the algal bloom season. Tissue samples were analyzed by Dr. Greg Boyer, University of Syracuse, New York, using HPLC with UV detection. Fish tissue samples collected in May, July, and September 2008 were below detection for total free microcystins (CH2M HILL 2009). PacifiCorp also collected mussel samples below Iron Gate dam during November 2008. A final report for these samples is expected by the end of 2009.

7.6.2.1 Yellow Perch Tissue Sampling

Yellow perch sampling is being conducted at both Copco and Iron Gate reservoirs. Sampling for yellow perch will occur twice during the anticipated bloom season. One sampling event will occur early in the bloom season (July) and the other towards the end of the bloom season (September). During each sampling event, a minimum of 5 (if possible) and up to 15 yellow perch, will be collected from each reservoir. Samples from each reservoir will be weighed and measured to fork length, wrapped in foil, and shipped in accordance with the SOP in Appendix A of the AIP 2009 Monitoring Plan.

In the future, fish sampling in the reservoirs should also be conducted prior to and soon after the collapse of the bloom, as recommended by OEHHA, to evaluate pre-bloom levels and cumulative impacts to evaluated fish species. Additionally, fish sampling in reaches of the river is anticipated.

7.6.2.2 Mussel Tissue Sampling

Mussel sampling is being conducted from a total of 7 locations and one control location, listed below in Table 7.7. The control sampling location (Trinity River) will only be sampled once during the anticipated bloom season (July through September). For all other locations, there will be 4 sampling events; one pre-bloom (May/June), two during the bloom (August and September) and one post-bloom (late October/November).

The proposed locations on the Klamath River below Iron Gate Dam are known to be fishing/harvesting locations, and will be used to evaluate potential ingestion exposure related to recreational, commercial and subsistence fishing activities. Mussel tissue sampling will also be used to support analysis of elevated concentrations in mussel tissues co-occurring with cyanobacterial abundance and elevated cyanotoxin levels in water samples.

Table 7.7: Sample sites in the Klamath River for 2009-2010 monitoring of cyanotoxins in mussel tissue

Location	Approximate RM	Sampling Entity
Klamath River at I-5 Rest Area	176	Karuk
Klamath River at Brown Bear River Access	157.5	Karuk
Klamath River at Seiad Valley	128.5	Karuk
Klamath River at Happy Camp	108.4	Karuk
Klamath River at Orleans	59.1	Karuk
Klamath River at Turwar	6.0	Yurok
Control sample from Trinity River near mouth	na	Yurok

For each Klamath River sampling event and location, five mussels will be collected from each location, and prepared for submittal to the laboratory in accordance with the *Environmental Sampling SOP* (AIP 2009 - Appendix A). Additionally, two water samples will be collected and analyzed for microcystin toxins by LC/MS/MS, and phytoplankton species and enumeration. The California Department of Fish and Game laboratory, in Rancho Cordova, CA, is providing analytical services for all tissue samples and water samples evaluated by LC/MS/MS.

7.6.2.3 Data Quality

Water quality monitoring data (cell count, and ELISA data presenting total microcystin concentrations) for the protection of public health, will be evaluated against the following water quality criteria and guidance. Data should be of sufficient quality to fully and unquestionably meet the following criteria and guidance.

To evaluate water quality data, criteria to be used for purposes of protecting public health include those presented in the California State Water Board 2008 Guidance about

Harmful Algal Blooms, for Monitoring and Public Notification², and criteria issued by California's Office of Environmental Health and Hazard Assessment (OEHHA). Exceedance of any of these criteria for the protection of human health and aquatic life may result in the posting of a waterbody by local health agencies:

- Surface scums are present containing toxigenic species³;
- *Microcystis aeruginosa* or *Planktothrix* cell densities $\geq 40,000$ cells/mL;
- Total microcystin concentrations ≥ 8 $\mu\text{g/L}$; and
- Others as specified in the California State Water Board 2008 Guidance.

To evaluate tissue samples, the current Advisory Tissue Level for one serving (8 oz uncooked, 6 oz cooked) will be applied to analytical results for cyanotoxin concentrations in mussel tissues (26 ng/g wet weight in June 2009, per OEHHA, August 6, 2008). For the protection of human health from tissue contaminated with microcystins, total microcystin concentrations for three or more individual mussels (samples composited, or discrete mussel data averaged) will be evaluated against the current criteria (OEHHA 2008).

7.7 TMDL Ambient Compliance and Trend Monitoring

7.7.1 Continuous/ Multi-Probe Monitoring

For each of the following parameters, capturing sub-daily variability is important to understanding the dynamics present in the system. Continuous monitoring devices will be deployed to address the period May to November, important for characterizing current conditions. Winter deployments can be minimal (December 1-March 31), with certain exceptions where winter water quality conditions are poorly understood.

- **Temperature** - controls rate reactions in aquatic system and can be a stressor to aquatic life.
- **Dissolved Oxygen** - is important to aquatic ecosystem function. Low concentrations can be a stressor to certain aquatic life.
- **pH** - conditions are important for aquatic life, with typical acceptable pH concentrations in a range of 6 to 9. At elevated pH, unionized ammonia can be toxic to aquatic life, a condition exacerbated by elevated temperatures.
- **Conductance** - represents ions that are in solution. This parameter is often used as a conservative constituent and to identify inputs or effects of land use practices.

² Per the posting guidelines established by the Blue Green Algae Work Group of the California State Water Resources Control Board, Department of Public Health, and Office of Environmental Health and Hazard Assessment; *Cyanobacteria in California Recreational Water Bodies; Providing Voluntary Guidance about Harmful Algal Blooms, Their Monitoring, and Public Notification*. Draft, September 2008.

³ When using the presence of scums to establish the need to post, staff trained in recognizing *Microcystis aeruginosa* scums must compile a photographic record as part of the monitoring program.

7.7.2 Water Quality Grab Sample Parameters

For the following parameter, limited sampling (frequency and locations) is proposed:

- **CBOD** - To address TMDL issues, sampling of CBOD will occur every two weeks from June to October, and approximately monthly the remainder of the year. Sampling for CBOD will occur at the following locations below Stateline: Link River Dam, below Keno Dam, above Copco Reservoir at Shovel Creek, and below Iron Gate Dam. Sampling procedures will be based on the USGS National Field Manual (2009) and as part of the studies recently completed by Sullivan (2008). Because many of the CBOD targets and allocations are below the method detection limit (MDL) the Regional Water Board proposes the following procedure for tracking compliance.

Analytical labs commonly assess results against two precision thresholds. The Method Detection Limit (MDL) is defined as the minimum concentration of a substance that can be measured and reported with 99% confidence that the analyte concentration is greater than zero. The reporting limit (RL) is defined as the lowest concentration at which an analyte can be detected in a sample and its concentration can be reported with a reasonable degree of accuracy and precision. Analytical results between the MDL and RL are often reported as estimated values.

The MDL and RL for TP are based on procedural results and can vary between laboratories. There are several commercial laboratories that can achieve an RL below the TP concentration targets. For example, the Dept. of Fish and Game laboratory in Rancho Cordova used by the California State SWAMP Program achieves a RL of 0.010 mg/L and a MDL of 0.005 mg/L, well below target concentration.

The MDL and RL for CBOD are equal at 3 mg/L. These levels are operationally defined and do not vary between laboratories.

Option 1) Analytical results of CBOD will be assessed using a 3-month running average for compliance evaluation against concentration targets. Analytical results reported as below the MDL will be assessed at one-half the MDL (i.e., 1.5 mg/L).

Option 2) Analytical results reported below the MDL for CBOD will be assumed to represent one-half the MDL (i.e., 1.5 mg/L). This assumption is a commonly used in water quality assessment (Helsel and Hirsch, 1992).

Alternatively, assessment of compliance with CBOD targets can be conducted using the concentration of Total Organic Carbon (TOC). The target concentrations were derived using a conversion factor applied to particulate and

dissolved organic matter. Analytical results of TOC can be converted to an equivalent concentration of CBOD using these conversions.

Sampling for the following parameters will occur from May through December at frequencies noted in Table 7.8. Capturing short term variability (biweekly or daily) may be important for several or all of these parameters, and could be added in future monitoring plans.

- **Inorganic/Organic N (ammonia, nitrate, nitrite, organic N)** - Inorganic nutrients (ammonia, nitrite, nitrate) are readily available for primary production. Total nitrogen (organic plus inorganic forms) is an indicator of overall status of an aquatic system. It is important to collect and assess/consider both organic and inorganic forms. Ammonia can be toxic (unionized ammonia) when elevated pH and temperature conditions are present. The conversion of ammonia to nitrite and nitrate consumes oxygen.
- **Inorganic/Organic P (orthophosphate, organic P)** - Inorganic nutrients (orthophosphate) are readily available for primary production. Total phosphorus (organic plus orthophosphate) is an indicator of overall status of an aquatic system. It is important to collect and assess/consider both organic and inorganic forms.
- **Particulate and Dissolved C (particulate and dissolved organic carbon)** - This is a measure of the organic matter within the system, and is necessary for the partitioning of organic matter fractions into particulate, dissolved, labile, and refractory. Organic matter consumes oxygen during decay and releases nutrients. Analysis of organic carbon is used to determine organic matter loads. Special studies will be used to identify stoichiometry of organic matter (C, N, and P fraction) and to partition particulate and dissolved matter into refractory and labile forms.
- **TSS/VSS (total and volatile suspended solids)** - TSS and VSS together define the organic (VSS) and inorganic (TSS-VSS) fraction of suspended material. This provides insight on bulk organic matter loads, and coupled with inorganic suspended solids can be used to estimate light extinction.
- **Alkalinity** - Understanding alkalinity, helps to identify the buffering capacity of waters and the ability of an aquatic system to resist changes in pH (e.g., in response to primary production).
- **Water Column Chlorophyll-a/Pheophyton** - This measure of chlorophyll-a and pheophyton in reservoirs can be used to estimate the standing crop of phytoplankton. Current modeling estimates of the export of carbon from the reservoirs do not include live algal biomass. An improved understanding of algal biomass export during the summer months would lead to improved estimates of downstream organic matter contributions from the reservoirs. Chlorophyll-a concentrations are also a key indicator of the probability of nuisance blooms dominated by blue-green algae. For the purpose of assessing the TMDL, summer mean target for chlorophyll-a should be calculated using the results of bimonthly surface grab samples from reservoir stations for the growing season (June through

September). Mid-winter measurements are not critical and could be reduced to monthly or once every two months.

- **Phytoplankton species** - The TMDL target for the reservoir for suspended algae chlorophyll-a = 10 µg/L (as a growing season mean - May to October) are linked to the public health monitoring for blue-green algae and the sampling regimen and protocol applies to both. Monitoring requirements to assess these targets for each reservoir with recreational uses are: a minimum of one sample per month at each of 3 near shore reservoir entry areas and 1 open water reservoir sample, collected in accordance with *Standard Operating Procedures, Environmental Sampling of Cyanobacteria for Cell Enumeration, Identification and Toxin Analysis* (June 2009) or other protocol as approved by the Regional Board. Interpretation of monitoring data for these targets will conform to World Health Organization guidance for low probability of adverse health effects, from the *Guidelines for Safe Recreational Water Environments* (Table 8.3), or superseding guidance. (WHO guidelines are also summarized in *Cyanobacteria in California Recreational Water Bodies, Blue-Green Algae Work Group of the State Water Resources Control Board, Department of Public Health, and Office of Environmental Health and Hazard Assessment* (Sept 2008).) Sampling is needed to identify species presence and absence. Determination of population variations can provide insight into trophic status, nutrient availability, blue-green algae species, potential toxins and health advisories. Consideration should be given to further reducing the sampling frequency in mid-winter.
- **Microcystin** - The California 2006 Section 303(d) list identified microcystin as an impairment in the segment from and including the Copco Reservoirs down to Iron Gate Dam, including the segment of Klamath River between those reservoirs. California's 2008 *Public Review Draft Staff Report for the 2008 Integrated Report for the Clean Water Act Section 305(b) Surface Water Quality Assessment and the 303(d) List of Impaired Waters* (Regional Water Board 2008) recommends that the mainstem Klamath River from downstream of Iron Gate Dam to the confluence of the Trinity River be listed as impaired for microcystin (Klamath River from Iron Gate Dam to Scott River - Middle Klamath River HA, and from Scott River to the Trinity River - Middle & Lower Klamath River HA). The target values for these parameters are *Microcystis aeruginosa* cell density = 20,000 cells/mL; and Microcystin = 4 µg/L. The sampling protocol and regimen are consistent with phytoplankton (above). These are minimum requirements, the AIP monitoring plan may exceed the proposed sampling regimen.
- **Preriphyton** (algal biomass) - The reach average is for the summer growing season and will be measured at a minimum of three points during the growing season (e.g., June, August, September) using the protocols described in: *Standard Operating Procedures for Collecting Stream Algae Samples and Associated Physical Habitat and Chemical Data for Ambient Bioassessments in California* (Fetscher et al. 2009). Sampling locations will be in close proximity to TMDL compliance points.

7.7.3 Trend Monitoring Locations, Parameters, Frequency

Table 7.8 provides a summary of the trend monitoring and special study monitoring locations. Several of the trend monitoring stations also double as public health monitoring stations. Some of the trend monitoring stations include public health parameters but are sampled at a reduced frequency compared to the primary public health stations identified in Table 7.6. The Klamath River TMDL monitoring network will require the participation of several organizations to conduct all of the proposed sampling. It may be necessary to reduce the number of stations over time as information regarding the consistency between stations becomes better known.

7.8 Additional Monitoring Needs and Key Questions for Special Study Consideration

Development and implementation of the Klamath River TMDL is an adaptive management process, responding at regular intervals to new information and new findings to ensure that management decisions and actions are directed to the most effective solutions. Following years of study and analysis many questions remain regarding the Klamath River basin water quality conditions. Enough is known that many fundamental decisions regarding load reductions can be safely made, however special studies are recommended. The purpose of this section is to provide a list of topics / issues that can be used to guide the development of future study plan proposals. These studies are described in a conceptual manner. Any final study designs would be developed in coordination with the Klamath Basin Water Quality Monitoring Coordination Group. The key questions are organized by topic or parameter. However, it is possible and desired that any proposed study address as many of the questions as possible.

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Table 7.8: Klamath River TMDL monitoring program trend monitoring location, parameter, frequency – summary table

Monitoring Location	Allocation and Target Compliance (C) Public Health (PH) /Special Study (SS)	Temperature (°C)	Dissolved Oxygen (mg/l)	pH (log[H+])	Conductance (uS/cm)	Inorganic/Organic N (mg/l)	Inorganic/Organic P (g/l)	Particulate and Dissolved C (mg/l)	TSS/VSS (mg/l)	Alkalinity (mg/l)	Water Column chl_a/Pheo (ug/l)	Phytoplankton species	Microcystin (ug/l)	LCMS confirmation	CBOD, mg/l
<i>Sampling Method:</i>		<i>T,P</i>	<i>P</i>	<i>P</i>	<i>P</i>	<i>G</i>	<i>G</i>	<i>G</i>	<i>G</i>	<i>G</i>	<i>G</i>	<i>G</i>	<i>G</i>	<i>G</i>	<i>G</i>
KR above Shovel Creek (Stateline) (RM-206.4)	C	H	-	-	-	M	M	M	M	M	M	M	M	M/S	M/BM
Copco Reservoir (RM-199.0)	C PH SS	VP	VP	VP	VP	M	M	M	M	M	M	M	M	-	
Downstream of Copco Reservoir (RM-195.0)	SS	H	-	-	-	M	M	M	M	M	M	M	M	-	-
Iron Gate Reservoir (RM-192.0)	C PH SS	VP	VP	VP	VP	M	M	M	M	M	M	M	M		
Iron Gate Hatchery (discharge)	C	Monitoring requirements will be addressed as part of the pending NPDES permit renewal.													
Klamath River below Iron Gate Dam (Hatchery Bridge) (RM-189.7)	PH SS	H	H	H	H	M/BM	M/BM	M/BM	M/BM	M/BM	M/BM	M/BM	W/S	M	M/BM
Klamath River at Shasta River (RM- 176.7)	PH SS	H	-	-	-	M	M	M	M	M	M	M	M		-
Klamath River at Brown Bear River Access (RM 150.0)	PH SS	P	P	P	P	M/BM	M/BM	M/BM	M/BM	M/BM	M/BM	M/BM	W/S	M	M/BM
Klamath River at Seiad Valley (RM - 128.5)	PH SS	H	H	H	H	M	M	M	M	M	M	M	M		-
Klamath River at Happy Camp (RM-108.4)	SS	H	-	-	-	M	M	M	M	M	M	M	M		-
Klamath River at Orleans (RM-59.1)	SS	H	H	H	H	M	M	M	M	M	M	M	M		-
Klamath River at Saints Rest Bar (RM-44.5)	C	H	H	H	H	M	M	M	M	M	M	M	M	M	
Klamath River at Weitchpec (RM-43.5)	SS	H	H	H	H	M	M	M	M	M	M	M	M		

Table 7.8 (cont.): Klamath River TMDL monitoring program trend monitoring location, parameter, frequency – summary table

Monitoring Location	Allocation and Target Compliance (C) Public Health (PH) /Special Study (SS)	Temperature (°C)	Dissolved Oxygen (mg/l)	pH (log[H+])	Conductance (uS/cm)	Inorganic/Organic N (mg/l)	Inorganic/Organic P (g/l)	Particulate and Dissolved C (mg/l)	TSS/VSS (mg/l)	Alkalinity (mg/l)	Water Column chl_a/Pheo (ug/l)	Phytoplankton species	Microcystin (ug/l) ^{xx}	LCMS confirmation	CBOD, mg/l
<i>Sampling Method:</i>		<i>T,P</i>	<i>P</i>	<i>P</i>	<i>P</i>	<i>G</i>	<i>G</i>	<i>G</i>	<i>G</i>	<i>G</i>	<i>G</i>	<i>G</i>	<i>G</i>	<i>G</i>	<i>G</i>
Klamath River below Trinity River (RM-38.5) > Tully Creek	SS	H	-	-	-	M	M	M	M	M	M	M	M	M	-
Klamath River at Turwar (RM-6.0)	SS	H	H	H	H	M	M	M	M	M	M	M			-
Klamath River Estuary (RM-0.5)	SS	-	-	-	-	M	M	M	M	M	M	M	M		-
Shasta River near mouth	C	H	H	H	H	M	M	M	M	M	M	M	-	-	-
Scott River near mouth	C	H	H	H	H	M	M	M	M	M	M	M	-	-	-
Salmon River near mouth	C	H	H	H	H	M	M	M	M	M	M	M	-	-	-
Trinity River near mouth	C	H	-	-	-	M	M	M	M	M	M	M	-	-	-

Key:

Sampling Method

T – thermistor

P – probe or data sonde (minimum seasonal deployment – April to November)

G – grab sample

Sampling Frequency

VP – vertical profile at stated sampling frequency

H – hourly measurements (in some instances sub-hourly data may be desired)

M – monthly sampling

Sampling Frequency

M/S – monthly sampling, seasonally from May through October

M/BM – Bi-monthly sampling May - October and monthly sampling the remainder of the year

W/S – weekly sampling, seasonally from June through September

7.8.1 Assessment of Primary Productivity Limitation

To address concerns that nutrient and organic matter reductions in the Klamath River basin could lead to limitations on primary productivity in the river system over time, careful monitoring and assessment of primary productivity and associated food web dynamics within the Klamath River is appropriate and warranted. Nutrient and organic matter conditions at Iron Gate tailrace and downstream locations should be compared to the monthly mean TP, TN, and CBOD “trigger” concentrations in Table 7.9. These “trigger” concentrations are based on the California allocation scenario, which represents conditions that comply with water quality standards without dams. If observed nutrient and organic matter conditions at Iron Gate tailrace or downstream locations are comparable to the “trigger” concentrations, and if there is evidence of potential limitations to primary productivity at levels deleterious to water quality standards, then the Regional Water Board should reevaluate the TMDL allocations and targets and nutrient controls in the basin or take other appropriate action.

Table 7.9: Nutrient (TP and TN) and organic matter (CBOD) monthly mean “trigger” concentrations (mg/L) at Iron Gate tailrace

	Jan	Feb	Mar	Apr	May	Jun
Average of TP	0.023 0.	028	0.029 0.	030	0.029 0.	025
Average of TN	0.302 0.	374	0.383 0.	393	0.370 0.	272
Average of CBOD	1.668 2.	513	2.629 2.	472	2.364 1.	325
	Jul	Aug	Sep	Oct	Nov	Dec
Average of TP	0.025 0.	024	0.024 0.	023	0.026 0.	029
Average of TN	0.238 0.	238	0.252 0.	284	0.320 0.	360
Average of CBOD	1.526 1.	442	1.117 1.	120	1.076 1.	416

7.8.2 Comprehensive Water Quality Monitoring

To bolster modeling analyses and significantly improve our understanding of water quality conditions in the Klamath River basin, an extended monitoring effort that repeatedly and simultaneously evaluates conditions along the entire length of the river, its impoundments, and the estuary, as well as for nearly all boundary conditions, would be ideal. Due to the size and complexity of this system, however, such a long-term and spatially-intense monitoring program is cost-prohibitive. Therefore, it is recommended that intensive monitoring be conducted for a two to three month period during the summer, when water quality conditions are of the most concern. Limiting the time span for data collection would ideally enable more concurrent data to be collected within the system and for critical inputs to the system.

Additionally, less intensive sampling during the fall, winter, and spring seasons is necessary to develop a reliable mass-balance for nutrient related constituents for the Klamath system. Currently the only method to estimate mass-balance conditions for free-flowing reaches and the reservoirs is to interpolate between a very sparse set of data points and limited information on system flows. A more complete mass-balance is of

high value to the ongoing TMDL adaptive management program and will be important in evaluating dam operation or removal scenarios. System wide mass balance monitoring will also provide information regarding nutrient and organic matter loading to the estuary.

Key data to collect, listed by location, are as follows:

- **Link River boundary condition:** Collect a full suite of data, including temperature, DO, total PO₄ (PO₄-T), NH₄/NH₃, NO₂/NO₃, CBOD₅, CBOD₂₀, Inorganic Suspended Solid (ISS), chlorophyll-a, algal biomass : chlorophyll-a ratio, algal C:N:P ratio, dissolved organic matter (C,N, and P), particulate organic matter (C, N, and P), alkalinity, and pH

Time span and frequency: Data should be collected on a **weekly** basis from approximately **June 1st to July 31st** (see footnote⁴), as this period covers the most critical water quality conditions at this location. For DO and temperature, continuous data (i.e., on an hourly-basis) is recommended. Monitoring pre-dawn and afternoon concentrations of several key nutrients, such as PO₄-T, NH₄/NH₃, NO₂/NO₃, and chlorophyll-a would be ideal, in order to characterize the magnitude of diurnal fluctuation.

- **Lost River Diversion Channel (LRDC):** Data are needed to characterize the contribution of loading to the Klamath River only during the period when water flows from the Lost River to the Klamath River. The same suite of temperature and water quality data recommended for Link River is necessary.

Again, flow data are necessary and assumed to be available.

- **Klamath Strait Drain (KSD):** The same suite of constituents noted above for Link River are also needed for KSD, in order to better characterize this boundary. Diurnal DO and temperature, and pre-dawn and afternoon nutrient monitoring are not as important.

The monitoring frequency should be weekly, and the starting time can be 4 days later than that for Link River (i.e., it can start from June 5th and extend to August 4th). This shift in dates takes into account the time of travel from Link River to the KSD entrance location.

- **Lake Ewauna/Keno Reservoir:** Monitoring is recommended at Miller Island and Hwy 66 for temperature (continuous), DO (continuous), NH₄, NO₂/NO₃, PO₄-t, chlorophyll-a, algae biomass, Org-N, Org-P, CBOD₅, CBOD₂₀, alkalinity, and pH.

⁴ The dates presented in this section are approximate and meant to reflect the recommended shift in sample days for the various monitoring locations.

These data would need to be monitored on a weekly basis. For Miller Island, the monitoring time span should be June 5th to August 4th (the same as for KSD). For the Hwy 66 station, a monitoring time span from June 7th to August 6th would be appropriate.

It would also be valuable to measure hydrogen sulfide levels at least one or two times over the course of the monitoring event, during the anoxic period.

- **Keno Reach:** A monitoring station should be set up at the end of the Keno Reach, before entry to J.C. Boyle Reservoir. Similar constituents and frequency as for KSD would be useful. The starting time, however, can be shifted to June 7th to August 6th (which is the same as for the Hwy 66 location).

These data would be useful in characterizing water quality processes occurring within the Keno Reach. They would also ensure more accurate representation of boundary conditions for the downstream J.C. Boyle model.

- **J.C. Boyle Reservoir:** Continuation of monitoring at the current location upstream of the dam is recommended. The same suite of parameters as for the Lake Ewauna/Keno Reservoir should be collected. The monitoring should be performed weekly from June 7th to August 6th.
- **Full Flow:** Four monitoring stations are recommended: 100 meters downstream of J.C. Boyle Dam, 100 meters after the Powerhouse return flow enters, within 100 meters of where the last spring enters, and at Stateline. The same suite of constituents as for the Lake Ewauna/Keno Reservoir are recommended. Monitoring should be performed weekly from June 7th to August 6th. Three parcel tracking events at twelve stations along the Klamath River should be initiated from (1) below the JC Boyle and below the last spring. Using the KBMP coordination framework and the model hydraulic simulation parcel sampling could be part of an optimized set of regular sampling events. The following locations should also be included in the parcel tracking sampling events: (2) above Copco; (3) above Iron Gate; (4) below Iron Gate; (5) above Shasta River; above (6) Scott River; (7) at Seiad Valley; (8) above Salmon River; (9) USGS station near Orleans; (10) at Weitchpec (above Trinity); (11) below Trinity River ; and (12) at Turwar. An estuary water quality sampling program needs to be established distinct from the run of river program. However for the parcel tracking events effort should be made to coordinate with ongoing estuary sampling events.

The purpose of this sampling recommendation is to better understand the nutrient dynamics of the Klamath mainstem (retention and loss) on a seasonal basis.

- **Springs:** Measure, if possible, the major springs along the full flow reach, for PO₄, NH₄, NO₂/NO₃, Alk, pH, temperature, and DO. Two to three weekly monitoring events should be conducted to evaluate the temporal variability of concentration. If

concentrations are highly variable, monitoring should be continued for a longer period.

- **Copco Reservoir:** Two monitoring stations are recommended: one at the upstream end and one near the dam. The same suite of constituents collected for Lake Ewauna/Keno Reservoir should be collected here, at a weekly frequency. For the upstream station, samples should be collected from June 7th to August 6th. For the downstream station, data should be collected from June 17th to August 16th.
- **Jenny Creek:** A monitoring station at the mouth of Jenny Creek is recommended. Similar constituents and frequency as for KSD would be useful. The monitoring period should be from June 17th to August 16th.
- **Iron Gate Reservoir:** Two monitoring stations are recommended: one that characterizes the outflow from Copco Reservoir before it enters Iron Gate Reservoir, and one immediately upstream of Iron Gate Dam. Constituents should be the same as for Lake Ewauna/Keno Reservoir and should be collected at a weekly frequency. The upstream station should be monitored from June 17th to August 16th and the downstream station from July 1st to August 31st.
- **Immediately Downstream of Iron Gate Dam:** One monitoring station should be located downstream of Iron Gate Dam - at the end of the turbulent region. Monitoring should include the same parameters collected for Link River. This will help to characterize inputs to the longest uninterrupted reach of the Klamath River. Samples should be collected on a weekly basis, with pre-dawn and post-dawn monitoring, if possible. Diurnal DO and temperature should be included. The time period should extend from July 1st to August 31st.
- **Low Gradient Reach Between Shasta and Scott Rivers:** This station has recently been demonstrated to have the highest rate of parasite infection of fish within the Klamath system. This station would also be crucial to understanding the nutrient dynamics of the reservoirs. To assess nutrient dynamics, diurnal hourly sampling events on three to four days from early spring to mid-fall would be useful. This would help to characterize daily variability in nutrient dynamics. The Iron Gate station should also be located at the same location as the station used by the Humboldt State University / Oregon State University Fish Health research teams. In addition to water chemistry the NNE parameter for benthic algal biomass should be sampled four times (late spring, early summer, late summer, and late fall). Monitoring should be conducted in close collaboration with the Fish Health Research Group (Bartholomew and Foot) to evaluate: planktonic food source enrichment from reservoir discharges; timing and concentration of parasite spore release; and parasite infection rates among fish and polychaetes.
- **Major Tributaries :** Based on modeling to date, it has been found that water quality from the minor tributaries do not have a significant impact on conditions in the

Klamath River. Therefore, monitoring these tributaries is not a high priority for understanding mainstem conditions and water quality drivers.

Monitoring the major tributaries, including Shasta, Scott, Salmon and Trinity, however, is important. Stations for these tributaries should be located as close to the tributary mouths as possible, while avoiding potential backwater effects from the Klamath River. Constituents monitored should be the same as for Lake Ewauna/Keno Reservoir. Monitoring should be conducted weekly from July 1st to August 31st. Additional samples should be collected for the Salmon and Trinity Rivers to evaluate day-to-day variability. These samples should be collected one or two days after the weekly monitoring data are collected at these locations.

- **Iron Gate to Turwar:** Monitoring stations downstream of the Shasta River, downstream of the Scott River, at Seiad Valley, upstream of the Salmon River, downstream of the Salmon River, upstream of the Trinity River, downstream of the Trinity River, and at Turwar are recommended. The same suite of constituents monitored for Lake Ewauna/Keno Reservoir should be monitored at these locations. Sampling should be conducted weekly from July 1st to August 31st.

These stations should also conduct three to four diurnal hourly sampling events to address daily variability in nutrient dynamics. The Iron Gate station should be located at the same location as the station used by the Humboldt State University / Oregon State University Fish Health research teams. In addition to water chemistry the NNE parameter for benthic algal biomass should be sampled four times (late spring, early summer, late summer, and late fall).

- **Estuary:** Two to three monitoring locations in the estuary should be selected (longitudinally). Constituents monitored should be the same as for Lake Ewauna/Keno Reservoir, with the addition of salinity.

A periphyton survey, as noted above for Iron Gate to Turwar, should also be conducted. Currently the model cannot accurately reproduce the significant diurnal fluctuation of DO in the estuary. This may be a result of periphyton growth.

- **Open Ocean Boundary Condition:** A monitoring station should be located in the Pacific Ocean, at a distance far enough from the estuary to avoid impacts from flushing. Tidal elevation, temperature, salinity, and the suite of constituents collected for Lake Ewauna/Keno Reservoir should be monitored. Both surface and bottom data are needed. Continuous tidal, temperature, and DO are recommended. The other parameters can be collected weekly. The sampling period should be from July 1st to August 31st.
- **Flow Gages and Flow Analysis:** Additional flow gages along the length of the river would be useful to further understand flow characteristics and the flow balance. This would improve hydrodynamic representation in the model, by refining representation of accretion/depletion. Currently, flow accretion is lumped with the minor tributaries

in the model. This introduces some amount of uncertainty. Ideally, a higher resolution survey would reduce the need to lump these accretions, and would serve to better represent their spatial variability.

- **Water Quality Monitoring for Accretions:** In the event that any significant accretions (e.g., springs) are identified, water quality monitoring is recommended. Monitoring should be conducted using a scheme similar to that for the springs downstream of J.C. Boyle Reservoir.
- **Updated Bathymetric Survey:** In 2004, a bathymetric survey was conducted in the estuary. A new survey is recommended to cover a larger area. The area should include that surveyed in 2004, but also extend to the sand bar (and characterize the dimensions of the sand bar opening) and include a survey of the bathymetry in the Pacific Ocean, just outside the estuary (since the model grid extends into the ocean). Conduct additional historical analysis of the pattern and frequency of the status (open or closed) of the estuary mouth. Include measurement of the estuary mouth in the bathymetry study. Measure flow at estuary mouth to better characterize tidal exchange with ocean.

7.8.3 Temperature / Fish Refugia

Temperature improvements in the Klamath River basin are contingent upon improvements from several contributing factors throughout the watershed. Achieving temperature standards in the Klamath River basin is critical for protecting beneficial uses of the basin, particularly in light of the real threats associated with global warming. The following are recommended special studies to better understand the opportunities for improving temperature conditions in the Klamath River basin:

- The influence of sediment delivery and tributary flows on thermal refugia volume in the Klamath River. Monitoring thermal refugia dimensions in relation to flows in tributaries, flows in the Klamath River, and sediment loads in the tributaries will lead to a better understanding of the most important factors limiting the availability of thermal refugia in the Klamath River.
- Monitoring of groundwater-surface water interaction in the Scott Valley. This monitoring is being conducted as part of the Scott River Temperature TMDL, and includes instream flow and temperature measurements, as well as monitoring of static water table height. The results of this study will contribute to a better understanding of potential temperature improvements in the Scott River.
- To better understand the status of fish access to the tributaries cross-sections surveys should be conducted at the mouth of each tributary to assess connection status to main stem Klamath. Conduct channel surveys of all major tributaries to assess the impact of excess sediment deposition and flow regime alteration on connection to the main stem Klamath.

7.8.4 Relationship of Water Quality Conditions and Fish Disease

The Klamath Fish Health Research team (Humboldt State University, Oregon State University, USFWS, and CA Fish and Game) is taking the lead on formulating key

questions, developing research proposals, and conducting the research to better understand and manage fish disease processes in the Klamath River basin. The annual Klamath Fish Health Conference held in Fortuna, California has provided an excellent forum for presentation and discussion of research results. The questions of interest to the Regional Water Board relate more specifically to how water quality conditions, especially those impacted by TMDL control strategies, affect the severity and magnitude of fish disease processes in the Klamath River. The Klamath Fish Health team is currently developing a fish disease model that eventually will incorporate water quality factors to develop estimates of fish infection and mortality rates within the Klamath mainstem.

- What monitoring information is needed to continue to develop the Klamath fish disease model algorithms?

7.8.5 Blue-Green Algae / Cyanotoxins

The California and Klamath Blue-Green Algae Work Groups meet on a regular basis and discuss results of ongoing monitoring and future research needs. Much is unknown about the algae species dynamics, ecological impacts, and the potential effectiveness of within reservoir mitigation strategies. The following are questions that will be raised at the existing forums for further refinement and possible recommendation for development into special study proposals.

- What environmental factors, or capabilities unique to the blue green algae contribute to the competitive advantage that the blue-green algal species exhibit in the California reservoirs during the peak summer growth period?
- How do environmental factors affect cyanotoxin production?
- How long does microcystin remain in tissue once an organism has been exposed?
- How long are the effects manifested within the affected tissues of various organisms?
- Proposed blue-green algae monitoring should consider tracking the depth that blue-algal cells descend to during their diurnal rising and sinking. Do blue-green algae cells reach the hypolimnion and have access to higher nutrient concentrations than those in the epilimnion? This could be a principal factor leading to their competitive advantage relative to other algal species during the late summer period.

7.8.6 Periphyton Characterization in the Mainstem Klamath River

Attached algae (periphyton) has a major impact on DO and pH diurnal patterns in the mainstem Klamath River. Periphyton is also believed to have a connection to the distribution and abundance of fish parasites (*C. Shasta*). Periphyton also plays an important role in nutrient dynamics (retention and loss) within the Klamath River. Therefore periphyton density / algal biomass is a key monitoring and TMDL implementation indicator.

- An improved characterization of periphyton / algal biomass conditions is needed on the Klamath River. Algal biomass should be sampled on four dates at seven locations beginning (1) below Iron Gate Dam (below the channelized reach). Other periphyton stations should include: (2) above the Shasta River; (3) above the Scott River; (4) at

Seiad Valley; (5) above Trinity; (6) below Trinity; and (7) at Turwar. The protocol should be consistent with the methods recommended by the Surface Water Ambient Monitoring Program Periphyton Technical Advisory Committee and should include a visual or photographic estimation method for those locations where due to flow conditions sampling in the mainstem is deemed to be unsafe. The sampling dates should include early spring, mid-summer, late summer, and late fall. Sampling events should note any obvious scour (early spring) or desiccation (late summer / late fall).

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